PATENT ABSTRACTS OF JAPAN

(11)Publication number : 10-262359
(43)Date of publication of application : 29.09.1998

(51)Int.Cl. H02K 29/00
H02K 21/16
H02P 6/18

(21)Application number : 09-062708
(22)Date of filing : 17.03.1997

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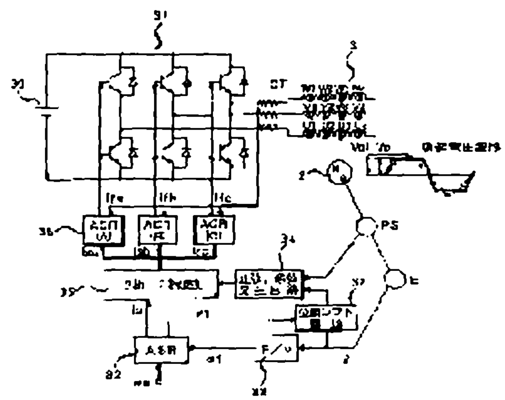
(54) PERMANENT MAGNET DYNAMO-ELECTRIC MACHINE

(57)Abstract:
PROBLEM TO BE SOLVED: To reduce the peak value of the induced voltage during a failure by setting the peak value of the generated induced voltage between terminals of a permanent magnet dynamo-electric machine to be the induced voltage value smaller than the peak value of the fundamental wave voltage.
SOLUTION: A permanent magnet dynamo-electric machine device is provided with a DC power source 30, an inverter 31 to be connected thereto, and a permanent magnet dynamo-electric machine to be directly connected to the output end of the inverter 31, and of the system to control the magnetic field system by weakening the magnetic field of the permanent magnet dynamo-electric machine by a phase shift circuit 37. The shape of the induced voltage satisfies the inequality of $Vp<Vp1$ where Vp is the peak voltage of the induced voltage generated between the terminals of the permanent magnet dynamo-electric machine, and Vp1 is the peak value of its fundamental wave voltage. The peak value of the induced voltage during the failure is reduced to obtain the permanent magnet dynamo-electric machine which is compact in size, light in weight and high in torque, and a magnet dynamo-electric machine device provided with an inverter which can be handled with a switching element small in current capacity.



LEGAL STATUS

[Date of request for examination]	19.07.2000
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3289635
[Date of registration]	22.03.2002
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

CLAIMS

[Claim(s)]
[Claim 1] DC power supply. Permanent magnet rotation electrical machinery by which rotational speed is controlled by the inverter connected to it. The means which carries out field-weaking control of this permanent magnet rotation electrical machinery. It is permanent magnet rotation electrical machinery equipment equipped with the above, and when peak value of the generating induced voltage between the terminals of the aforementioned permanent magnet rotation electrical machinery is set to pinch off voltage and peak value of the fundamental-wave voltage is set to pinch off voltage1, it is characterized by making it become the induced-voltage value of pinch off voltage<pinch off voltage1.
[Claim 2] The permanent magnet rotation electrical-machinery equipment characterized by making it become the induced-value of Vm<pinch off voltage when the voltage value of the center of the generating induced voltage between the terminals of permanent magnet rotation electrical machinery sets to Vm and peak value of the generating induced voltage sets to pinch off voltage in the permanent magnet rotation electrical-machinery equipment which comes to have DC power supply, the permanent magnet rotation electrical machinery by which rotational speed is controlled by the inverter connected to it, and the means which carries out field-weaking control of this permanent magnet rotation electrical machinery.
[Claim 3] Permanent magnet rotation electrical machinery equipment characterized by making coil width of face of permanent magnet rotation electrical machinery almost equal to the width of face of the magnetic pole of a permanent magnet rotator in claim 2 publication.
[Claim 4] Permanent magnet rotation electrical machinery equipment characterized by making the opening length based on [of a permanent magnet rotator] magnetic poles larger than the opening length of the pole tip in a claim 1 or two publications.
[Claim 5] Permanent magnet rotation electrical machinery equipment characterized by making it two or more stator salient poles which wound the stator winding belonging to the same phase in a claim 1 or two publications become a position in phase altogether electrically.
[Claim 6] Permanent magnet rotation electrical machinery equipment characterized by N2/N1 being two or more when it has the constant torque range of a low rotational frequency, and a constant output operating range at the time of high speed and the maximum engine speed of N1 and the constant output range is set to N2 for the maximum engine speed of the constant torque range in a claim 1 and two publications.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to permanent magnet rotation electrical machinery equipment, and permanent magnet rotation electrical machinery equipment equipped with the inverter which ends with small lightweight ones, the permanent magnet rotation electrical machinery of high torque, and a switching element with small current capacity is offered.
[0002]
[Description of the Prior Art] That it is lightweight the amount of the battery loaded as an electric vehicle being limited, and securing 1 charge mileage enough by it small to eye a required hatchet as for the driving motor used in electric vehicles, especially an electric vehicle and an efficient thing are desired. On the other hand, to be high torque and to be the permanent magnet rotation electrical machinery which weakened and was suitable for the field are demanded for reservation of the acceleration performance as vehicles, and the maximum high speed etc.
[0003] It is indicated by JP,2-324232,A that permanent magnet rotation electrical machinery is effective as a motor suitable for the above conditions, and the permanent magnet rotation electrical machinery of the method which generates effectively the torque especially by the permanent magnet and the reluctance torque using the saliency is effective.
[0004]
[Problem(s) to be Solved by the Invention] According to the above-mentioned conventional technology, the composition which juxtaposed the auxiliary magnetic pole which arranges a permanent magnet in the rotor core which has permeability higher than a permanent magnet, and is constituted from a permanent magnet and a rotor core by the hoop direction is shown. On the other hand, a stator is composition which makes smooth rotating magnetic field by the stator of a distributed winding synchronizing with rotation of a permanent magnet rotator.
[0005] Thus, a permanent magnet is arranged in the rotor core which consists of magnetic material which has permeability higher than a permanent magnet, i.e., it weakens by considering as internal magnet rotator composition, a field becomes possible, and operation to a high-speed field is attained efficient.
[0006] However, in the rotation electrical machinery which weakens and carries out the field of the permanent magnet, if an inverter breaks down at the time of high-speed operation, field-weaking control will become impossible, the high voltage will occur between the lines of permanent magnet rotation electrical machinery, and big power will be returned to a battery. A slam on the brake arises in the 1st, and this invites the instability of a run vehicles posture to it. There is a problem in the 2nd in that a battery, a smoothing capacitor, an inverter, etc. may be made to damage.
[0007] Moreover, with the above-mentioned conventional technology, since there are few rates of the magnetic flux of the permanent magnet generally contributed to torque generating, although the induced voltage to generate is pressed down comparatively small, the generating induced voltage in the maximum high speed will still become very big.
[0008] Furthermore, in the case of the permanent-magnetic motor of a distributed-winding stator etc., it may become much more serious by jumping of the induced voltage by the slot ripple.
[0009] Although there are a method of inserting a contactor in the 1st between an inverter and rotation electrical machinery, and separating permanent magnet rotation electrical machinery from an inverter at the time of failure and a method of setting an induced voltage as the 2nd low in order to avoid the above in fact, by the 1st method, the space of a contactor, a weight, etc. are necks and the dominance point over other motors, for example, induction motor, is spoiled. Moreover, the ratio expected to a reluctance torque component at the 2nd point is large, and there is a fault which makes the result to which current required to generate [enlarging the physique of a motor and] torque increases, and the current capacity of an inverter is made to increase in vain produce.
[0010] this invention reduces the peak value of the induced voltage at the time of failure, and aims at offering permanent magnet rotation electrical machinery equipment equipped with the inverter which ends by this with small lightweight ones, the permanent magnet rotation electrical machinery of high torque, and a switching element with small current capacity.
[0011]
[Means for Solving the Problem] In the permanent magnet rotation electrical machinery equipment which comes to have DC power supply, the permanent magnet rotation electrical machinery by which rotational speed is controlled by the inverter connected to it, and the means which carries out field-weaking control of this permanent magnet rotation electrical machinery, this invention is attained by making it make with the induced-voltage value of pinch off voltage<pinch off voltage1, when peak value of the generating induced voltage between the terminals of the aforementioned permanent magnet rotation electrical machinery is set to pinch off voltage and peak value of the fundamental-wave voltage is set to pinch off voltage1.
[0012] When [of this invention] the voltage value of the center of the generating induced voltage between the terminals of permanent magnet rotation electrical machinery is set to Vm and peak value of the generating induced voltage is preferably set to pinch off voltage, it is attained by having made it make with the induced-voltage value of Vm<pinch off voltage.
[0013] It is preferably attained by [of this invention] having made coil width of face of permanent magnet rotation electrical machinery almost equal to the width of face of the magnetic pole of a permanent magnet rotator.
[0014] It is preferably attained by [of this invention] making the opening length based on [of a permanent magnet rotator] magnetic poles consist of opening length of the pole tip size.
[0015] It is attained when two or more stator salient poles which wound the stator winding which belongs to the same phase of

this invention preferably arrange all in a position in phase electrically.
[0016] It is attained [of this invention] when it has the constant torque range of a low rotational frequency, and a constant output operating range at the time of high speed, and the maximum engine speed of N1 and the constant output range is preferably set to N2 for the maximum engine speed of the constant torque range, and N2/N1 is two or more.
[0017]
[Embodiments of the Invention] Hereafter, the example of this invention is explained.
[0018] The structure of the permanent magnet rotation electrical machinery of this invention is shown in drawing 2 , and the cross-section structure of the permanent magnet rotation electrical machinery of this invention is shown for one example of the permanent magnet rotation electrical machinery equipment in connection with this invention in drawing 1 in drawing 3 .
[0019] Permanent magnet rotation electrical machinery consisted of a stator 1 and a rotator 2 in drawing 2 and drawing 3 , and this stator 1 consisted of an iron core by which the laminating was carried out, and has looped the slot section 11 around the stator winding 3 through an insulating material. Here, stator structure is distributed-winding stator structure currently generally used widely, for example, a stator core consists of the yoke section 13 which forms a magnetic circuit by the tooth part 12, and a stator winding 3 is contained by the slot section 11 from the slit section 14 of the portion near the opening side of a stator core.
[0020] the permanent magnet insertion prepared in the layer-built iron core whose rotator 2 is a high permeability magnetic material, and which it becomes from a silicon steel, and its layer-built iron core -- it consists of the permanent magnet 22 and shaft 4 which were inserted in the hole 21 the permanent magnet insertion which the layer-built iron core which consists of this high permeability magnetic material was equipped with the auxiliary magnetic pole section 23 prepared between the adjacent permanent magnets 22, the pole piece section 24 prepared in the periphery of a permanent magnet 22, and the yoke section 13, and was described above in this yoke section -- a hole 21 and the hole which lets a shaft 4 pass are pierced It shall rotate counterclockwise and the hand of cut of this permanent magnet rotator 2 shall be operated as a motor. Here, since the permanent magnet 22 to be used is made into the rectangular parallelepiped, as compared with an arc-shaped magnet, a dimensional accuracy tends to secure it, and high-speed rotation can be presented with it without the balance work of a rotator. Moreover, the neodium magnet which is an aperiodic compass shall be used for a permanent magnet 22.
[0021] Cross-section structural drawing of the permanent magnet rotation electrical machinery of this invention is shown in drawing 3 . The stator 1 of rotation electrical machinery is being fixed to the inner skin of the housing 10,101 of a couple. Here, as for the slot section 11 of a stator core, the example of 1 has shown the number of slots per ******** to the pole 8 of a permanent magnet rotator by 24 pieces. It is the same even if this increases with 2 and 3.
[0022] The shaft 4 is held free [rotation] through Bearings 10a and 10b at housing 10,101. PS is a magnetic pole position transducer which detects the position of the permanent magnet 22 of a rotator 2 here, and E is an encoder which detects the position of a rotator 2. Rotation electrical machinery is composition in which an operation control is carried out by the signal of this magnetic pole position transducer PS, and the output signal of Encoder E through a control unit. E is a position sensor for speed control.
[0023] The control circuit of the permanent magnet rotation electrical machinery equipment of this invention is shown in drawing 1 .
[0024] In drawing, power is supplied to the stator winding 3 of a polyphase through an inverter 31 from DC power supply 30.
[0025] In a speed control circuit (ASR) 32, speed instruction omegas and speed omega f to actual speed-difference omegae which are obtained from the positional information theta from Encoder E through F/V converter 33 is computed, and the angle of rotation theta 1 of the torque instructions Is, i.e., current instructions, and a rotator 2 is outputted to this by PI control (P : a proportional, I: integration term) etc.
[0026] On the other hand, by the sine wave and the cosine wave generator 34, the induced voltage of each coil (here three phase circuit) of a stator winding 3, a sinusoidal output in phase, or the sinusoidal output that carried out the phase shift if needed is generated from the pulse theta from the position transducer PS and Encoder E which detect the position of the permanent magnet magnetic pole of a rotator 2, i.e., the positional information of a rotator.
[0027] In the 2 phase-three-phase-circuit conversion circuit 35, the current instructions Isa, Isb, and Isc are outputted to each phase according to the output of the current instructions Is, a sine wave, and the cosine wave generator 34. Each phase has the current control system (ACR) 36 individually, respectively, sends the signal according to the current detecting signals Ifa, Ifb, and Ifc from the current instructions Isa, Isb, and Isc and the current detector CT to an inverter 31, and controls each phase current. In this case, the current of each phase composition always forms in field magnetic flux a right angle or the position (the control which magnetomotive force of composition of each phase current is advanced 90 degrees or more from permanent magnet is called field-weaking control) current which carried out the phase shift, and by this, it is a non-commutator and it can acquire a property equivalent to a direct current machine.
[0028] By controlling the synthetic vector of the armature magnetomotive force which the current passed to a stator winding 3 with a control unit builds with the above composition to turn to a hand-of-cut side from the center position of the auxiliary magnetic pole section 23, rotation electrical machinery can generate the reluctance torque by the auxiliary magnetic pole section 23 other than the torque by the permanent magnet 22, and can operate it as a motor of high torque.
[0029] As this invention shows to drawing 1 , in the above composition DC power supply 30, In the permanent magnet rotation electrical machinery equipment of the method which is equipped with the inverter 31 connected to it, and the permanent magnet rotation electrical machinery by which the direct file was carried out to the outgoing end of an inverter 31, and carries out field-weaking control of the permanent magnet rotation electrical machinery by the phase shift circuit 37 When peak voltage of the generating induced voltage between the terminals of permanent magnet rotation electrical machinery is set to pinch off voltage and peak value of the fundamental-wave voltage is set to pinch off voltage1, it is characterized by making it make with the induced-voltage configuration of pinch off voltage<pinch off voltage1.
[0030] At a low speed (range to a certain rotational frequency), generating of large torque is possible for the torque characteristic for which the driving motor used for electric vehicles, such as an electric vehicle, is asked, and it is desired in the range to which the capacity of an inverter 31 does not become as large as possible in the high-speed field exceeding it for operation of a constant output to be possible. For this reason, at a low speed, generally, operation in the constant output range of the constant torque operating range and high speed in within the limits of the allowable current of the switching element of an inverter 31 is performed.
[0031] Generally the torque T of a permanent magnet motor is. T= (E0, Iq+ (Xq-Xd), and Id-Iq) / omega -- (1)
Here, it is an E0:induced voltage. omega: The 1st term is a torque component by the permanent magnet 22 by the reactance (1) formula of the current Xq of the angular rate of rotation Id, Iq:d, and q shaft, Xd:d, and q shaft, and the 2nd term is a reluctance

torque component by the auxiliary magnetic pole section 23.
[0032] In order to enlarge torque, it is necessary to use the torque by reluctance, and the torque by the permanent magnet for the maximum. Therefore, the law to which the induced voltage of a permanent magnet was made to increase can make small current capacity of the switching element of an inverter 31.
[0033] On the other hand, in the field of a high-speed rotational frequency, for a constant output, required torque becomes small and makes neither torque by reluctance, nor torque by the permanent magnet the phase which can take out the greatest torque over the same current. Here, it operates by the so-called field-weaking control which weakens the magnetic flux of a permanent magnet 22 and lowers the induced voltage by the permanent magnet. It carries out to below the terminal voltage that lowers the induced voltage by the permanent magnet by this, therefore is applied to permanent magnet rotation electrical machinery, and power comes to be supplied and rotation can be made more possible than DC power supply to high speed.
[0034] If priority is given to low-speed torque on this condition and an induced voltage is raised, it is necessary to weaken at high speed and to enlarge a field.
[0035] Element pressure-proofing of the induced voltage of a permanent magnet of an inverter 31 by field-weaking control here, a control unit is normal, if working And although the range of pressure-proofing, such as a capacitor formed between the input terminals of an inverter, is not exceeded It operates normally to high-speed operation, when an inverter breaks down after that, it weakens and a field becomes impossible, a big induced voltage is built over the direct inverter 31 and a capacitor, and there are also fear of breakage and a possibility of causing a big brake force by returning big power to DC power supply.
[0036] Therefore, in order to make element capacity of an inverter small, it suits and it is necessary to attain the consistent technical problem of making generating of big torque, and the maximum of an induced voltage reduce. On the other hand, generally the slit 14 which contains a stator winding 3 in the slot section 11 as mentioned above is formed in the stator core of permanent magnet rotation electrical machinery. The influence of this slit becomes a wave like drawing 4 (a) depending on selection of the angle tau 1 of a permanent magnet with the permanent magnet rotation electrical machinery of a mold which has the auxiliary magnetic pole section 23 which uses positively reluctance torque as shown by drawing 2 . That is, induced-voltage wave Vm=pinch off voltage of a core will become large.
[0037] the effective value of the induced voltage which influences torque as a result since the element of an inverter 31 and the voltage tolerance dose of a capacitor will be decided by the maximum pinch off voltage of an induced voltage if failure of the inverter 31 in a high-speed field is considered by such wave -- small -- not carrying out -- in order not to obtain, therefore to acquire the same torque, there is a fault to which the current capacity of an inverter element must be made to increase
[0038] In this invention, as a result of verifying in a parameter the angle of the permanent magnet tau 1 shown by drawing 2 , it found out changing with angles to an induced-voltage wave, as shown in drawing 4 (a), (b), and (c).
[0039] Drawing 4 is eight poles and a 48-slot example of illustration, a solid line shows the induced voltage between lines, and a wavy line shows a part for the fundamental wave.
[0040] Drawing 4 (a) is the angle of a permanent magnet tau 1, and the ratio of **** taup 0.63 By the case where it carries out, in [part / fundamental-wave / pinch off voltage 1 / of an induced voltage] this case, the maximum pinch off voltage of the induced voltage of rotation electrical machinery is equal to the value Vm of the core of an induced voltage, and the value becomes large.
[0041] Drawing 4 (b) is the angle of a permanent magnet tau 1, and the ratio of **** taup 0.58 By the case where it carries out, in [part / fundamental-wave / pinch off voltage 1 / of an induced voltage] this case, the maximum pinch off voltage of the induced voltage of rotation electrical machinery is higher than the value Vm of the core of an induced voltage, and becomes small.
[0042] Drawing 4 (c) is the angle of a permanent magnet tau 1, and the ratio of **** taup 0.53 By the case where it carries out, in [part / fundamental-wave / pinch off voltage 1 / of an induced voltage] this case, the maximum pinch off voltage of the induced voltage of rotation electrical machinery is larger than the value Vm of the core of an induced voltage, and becomes small.

[0043] pinch off voltage/pinch off voltage1 and Vm/pinch off voltage to the angle of a permanent magnet tau 1 and the ratio of **** taup are shown in drawing 4 (d).
[0044] Here, the fundamental-wave part pinch off voltage 1 of an induced voltage has the desirable larger one directly with regards to torque. On the other hand, as for the maximum pinch off voltage of an induced voltage, it is desirable that it is small as much as possible to making it operate till high speed. Therefore, making small the ratio of pinch off voltage/pinch off voltage1 is called for. At drawing 4 (d), the angle of a permanent magnet tau 1 and the ratio of **** taup are 0.6. The following 1, i.e., pinch off voltage/pinch off voltage, is 1.0. The following (pinch off voltage<pinch off voltage1) is good. On the other hand, although the value Vm of the core of an induced voltage does not have a meaning directly, the range set to Vm/pinch off voltage<1 as drawing 4 (d) shows, and the above-mentioned range correspond well. That is, pinch off voltage<pinch off voltage1 can be honored publicly by Vm<pinch off voltage.
[0045] As mentioned above, current capacity of an inverter element can be made small by carrying out, as shown in drawing 4 (b) and (c).
[0046] an effect has the above effect, so that the value which is N2/N1 is large, when it has the constant torque range of a low rotational frequency, and a constant output operating range at the time of high speed and the maximum engine speed of N1 and the constant output range is set to N2 for the maximum engine speed of the constant torque range That is, it is because the need of weakening the magnetic flux of a permanent magnet in a high-speed region becomes large. Here, this value can demonstrate the above-mentioned effect or more by two.
[0047] Other examples of the rotation electrical machinery of the permanent magnet rotation electrical machinery equipment of this invention are shown in drawing 5 .
[0048] The same sign as drawing 2 shows the same component part. Here, the composition by which the stator winding (for example, U1, U2, U3, U4) which belongs in phase has been arranged electrically altogether in the position in phase shows. Since the higher harmonic of an induced voltage occurs in all stator windings by considering as the same phase, it does not decrease, but it becomes easy to generate the induced voltage of a trapezoidal shape.
[0049] Here, it considered as the composition which enlarges the opening section of the pole piece section 24 of the periphery section of the center of a permanent magnet rotator. As the above configuration shows to drawing 5 (b), the induced voltage of permanent magnet rotation electrical machinery can become stair-like, can be made into pinch off voltage<pinch off voltage1, and can acquire the same effect as explanation by drawing 4 .
[0050] Other examples of the rotation electrical machinery of the permanent magnet rotation electrical machinery equipment of

this invention are shown in drawing 6 . The same sign as drawing 2 shows the same component part. Here, it is characterized by making the stator of permanent magnet rotation electrical machinery into a concentrated winding. It is the composition that the stator winding which belongs wind a stator winding intensively and in phase also here has been arranged altogether electrically in the position of the same phase.
[0051] Even if a rotator is composition which has arranged the permanent magnet over a perimeter mostly by considering as the above composition, as shown in drawing 5 (b), the induced voltage of permanent magnet rotation electrical machinery can be made stair-like. By this, it can consider as pinch off voltage<pinch off voltage1, and the same effect as explanation by drawing 4 can be acquired.
[0052] In addition, if the above permanent magnet rotation electrical machinery is applied to electric vehicles, especially an electric vehicle, a small efficient lightweight permanent magnet rotation electrical machinery driving gear can be carried, and an electric vehicle with long 1 charge mileage can be offered. Moreover, the high electric vehicles of safety can be offered. Moreover, the above can apply also about the permanent magnet rotation electrical machinery equipment which has a torque control function, although the permanent magnet rotation electrical machinery equipment which has a speed-control function (ASR) as a control unit was described. Moreover, regardless of the rotation electrical machinery which has the opening of shaft orientations as rotation electrical machinery and a generator, a motor and an introvert type, an abducted type, and a linear type, it is applicable.
[0053]
[Effect of the Invention] According to the above composition, permanent magnet rotation electrical machinery equipment equipped with the inverter which ends with small lightweight one, the permanent magnet rotation electrical machinery of high torque, and a switching element with small current capacity can be offered.

[Translation done.]

DESCRIPTION OF DRAWINGS

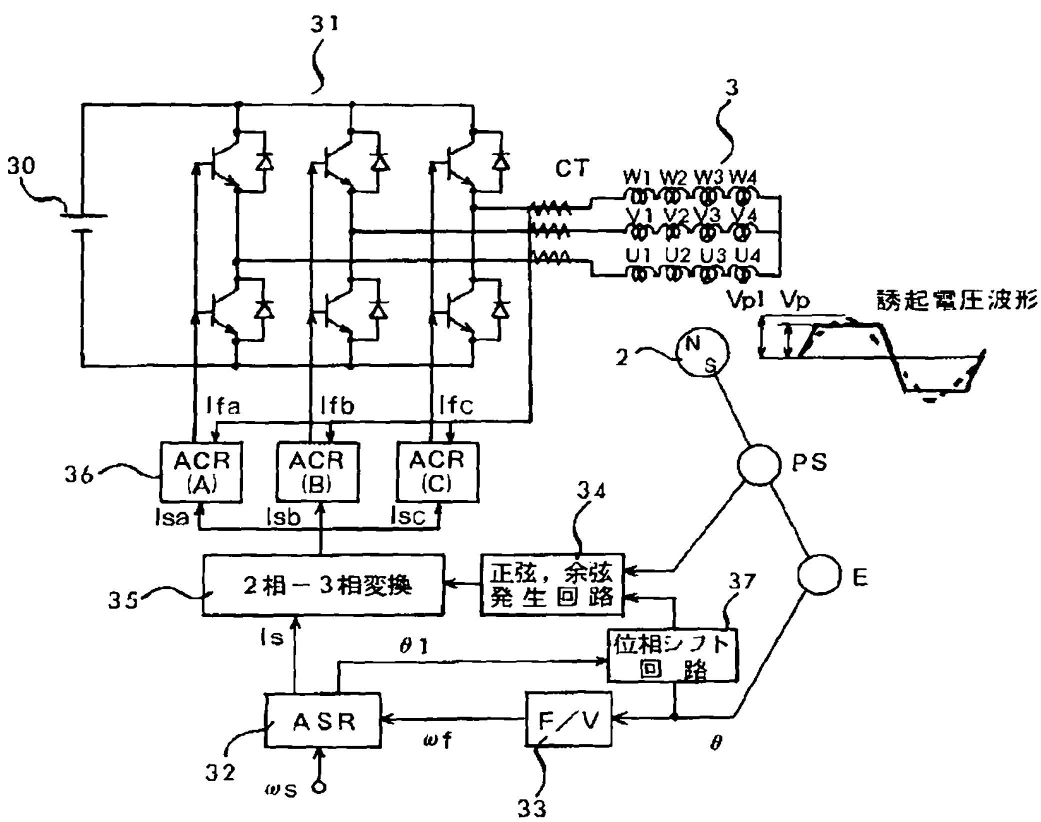
[Brief Description of the Drawings]
[Drawing 1] The permanent magnet rotation electrical machinery equipment of this invention is shown.
[Drawing 2] The permanent magnet rotation electrical machinery of this invention is shown.
[Drawing 3] The cross section of the permanent magnet rotation electrical machinery of this invention is shown.
[Drawing 4] Explanatory drawing of the induced-voltage wave of this invention of operation is shown.
[Drawing 5] Other examples of the permanent magnet rotation electrical machinery of this invention are shown.
[Drawing 6] Other examples of the permanent magnet rotation electrical machinery of this invention are shown.
[Description of Notations]
1 -- stator and 2 -- -- a rotator, 3 -- stator winding, 11 -- slot section, and 12 -- -- a stator tooth part (salient pole section), 13 -- stator yoke section, and 21 -- permanent magnet insertion -- a hole, 22 -- permanent magnet, and 23 -- -- the auxiliary magnetic pole section, 24 -- pole piece section, 31 -- inverter, and 32 -- -- a speed control circuit (ASR), 33 -- F/V converter, 34 -- sine wave, a cosine wave generator, and 36 -- -- a current control system (ACR

[Translation done.]

DRAWINGS

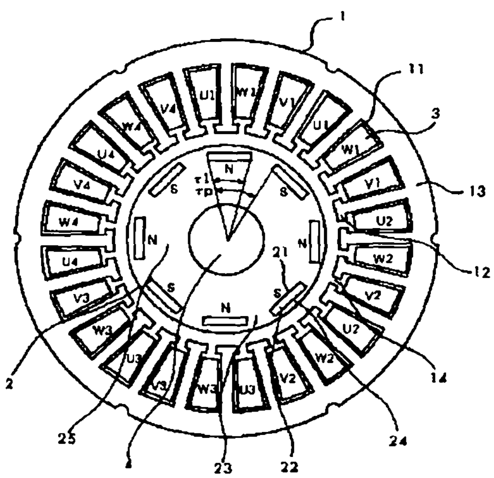
[Drawing 1]

図 1



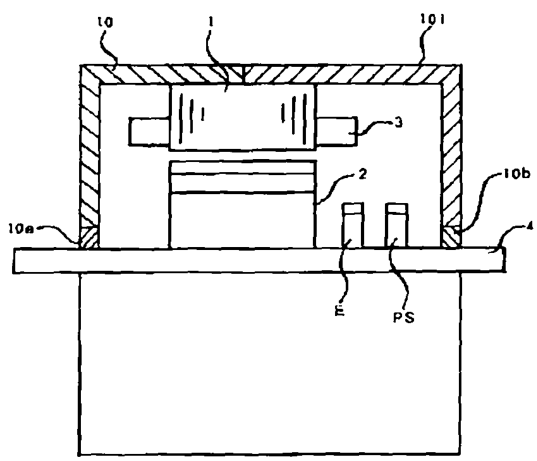
[Drawing 2]

図 2



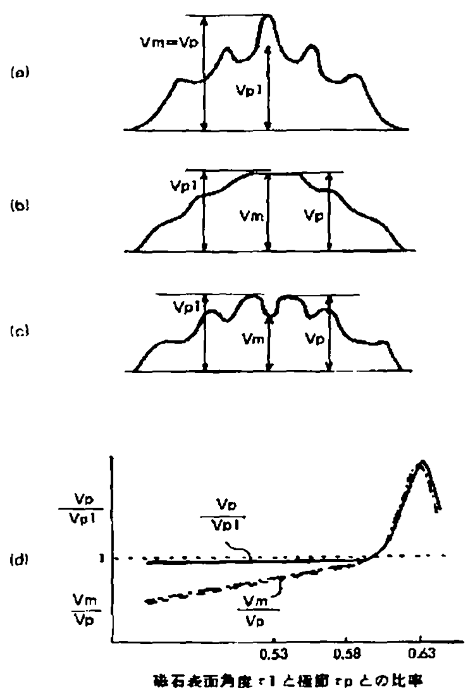
[Drawing 3]

図 3



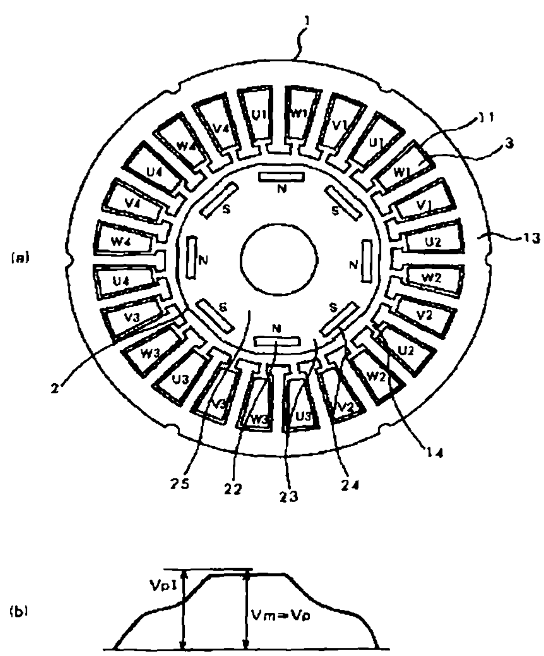
[Drawing 4]

図 4



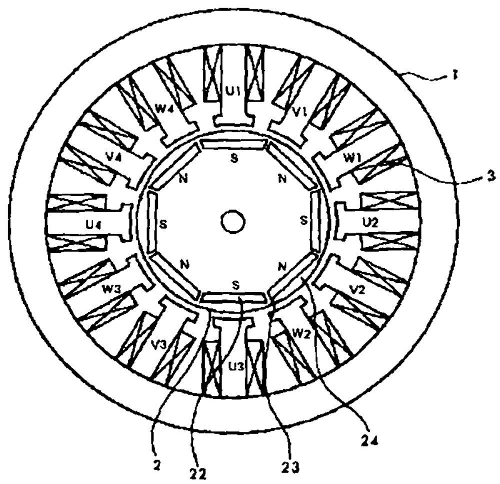
[Drawing 5]

図 5



[Drawing 6]

図 6



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(19)日本国特許庁（ＪＰ）　　(12) **公開特許公報**（Ａ）　　(11)特許出願公開番号

特開平10－262359

(43)公開日　平成10年(1998) 9月29日

(51)Int.Cl.⁶	識別記号	Ｆ Ｉ		
Ｈ０２Ｋ　29/00		Ｈ０２Ｋ　29/00		Ｚ
21/16		21/16		Ｍ
Ｈ０２Ｐ　6/18		Ｈ０２Ｐ　6/02		３７１Ｓ

審査請求　未請求　請求項の数６　ＯＬ　（全 ７ 頁）

(21)出願番号　特願平9－62708

(22)出願日　平成９年(1997)３月17日

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(54)【発明の名称】　永久磁石回転電機装置

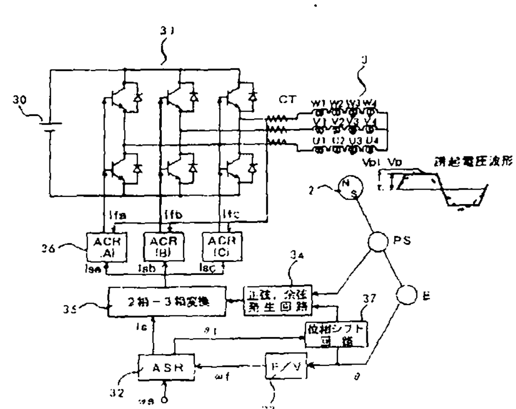
(57)【要約】

【課題】小形軽量，高トルクの永久磁石回転電機、及び電流容量の小さなスイッチング素子ですむインバータとを備えた永久磁石回転電機装置及びこれを用いた電動車両を提供する。

【解決手段】かつ永久磁石回転電機を弱め界磁制御する方式の永久磁石回転電機装置において、永久磁石回転電機の端子間の発生誘起電圧のピーク電圧をＶｐとし、その基本波電圧のピーク値をＶｐ１としたとき、Ｖｐ＜Ｖｐ１の誘起電圧形状となさしめる。

【効果】小形軽量，高トルクの永久磁石回転電機、及び電流容量の小さなスイッチング素子ですむインバータとを提供できる。

図　1



1

【特許請求の範囲】

【請求項１】直流電源と、それに接続されるインバータにより回転速度が制御される永久磁石回転電機と、該永久磁石回転電機を弱め界磁制御する手段とを備えてなる永久磁石回転電機装置において、

前記永久磁石回転電機の端子間の発生誘起電圧のピーク値をＶｐとし、その基本波電圧のピーク値をＶｐ１としたとき、Ｖｐ＜Ｖｐ１の誘起電圧値となるようにしたことを特徴とする永久磁石回転電機装置。

【請求項２】直流電源と、それに接続されるインバータにより回転速度が制御される永久磁石回転電機と、該永久磁石回転電機を弱め界磁制御する手段とを備えてなる永久磁石回転電機装置において、

永久磁石回転電機の端子間の発生誘起電圧の中心の電圧値をＶｍとし、その発生誘起電圧のピーク値をＶｐとしたとき、Ｖｍ＜Ｖｐの誘起電圧値となるようにしたことを特徴とする永久磁石回転電機装置。

【請求項３】請求項２記載において、永久磁石回転電機のコイル幅を永久磁石回転子の磁極の幅にほぼ等しくしたことを特徴とする永久磁石回転電機装置。

【請求項４】請求項１もしくは２記載において、永久磁石回転子の磁極中心の空隙長を磁極端の空隙長より大きくしたことを特徴とする永久磁石回転電機装置。

【請求項５】請求項１もしくは２記載において、同じ相に属する固定子巻線を巻回した複数の固定子突極が電気的にすべて同相の位置になるようにしたことを特徴とする永久磁石回転電機装置。

【請求項６】請求項１、２記載において、低回転数での定トルク範囲と高速時の定出力運転範囲とを有し、かつ定トルク範囲の最高回転数をＮ１、定出力範囲の最高回転数をＮ２としたとき、Ｎ２／Ｎ１が２以上であることを特徴とする永久磁石回転電機装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は永久磁石回転電機装置に係り、小形軽量、高トルクの永久磁石回転電機、及び電流容量の小さなスイッチング素子ですむインバータとを備えた永久磁石回転電機装置を提供するものである。

【０００２】

【従来の技術】電動車両、特に電気自動車において使用される駆動電動機は電気自動車として積載されるバッテリの量が限定され、かつそれで十分一充電走行距離を確保することが必要なために小型軽量、高効率であることが望まれる。一方、車両としての加速性能、最高速の確保等のために高トルクであること、弱め界磁に適した永久磁石回転電機であることが要求される。

【０００３】以上の条件に適した電動機として永久磁石回転電機が有効であり、特に永久磁石によるトルクと突極性を利用したリラクタンストルクを有効に発生する方式の永久磁石回転電機が効果的であることが、特開平２－324232 号で開示されている。

2

【０００４】

【発明が解決しようとする課題】上記従来技術によれば、永久磁石を永久磁石よりも高い透磁率を有する回転子鉄心の中に配置し、かつ周方向に永久磁石と回転子鉄心とで構成される補助磁極とを並置した構成を示している。一方、固定子は分布巻の固定子で永久磁石回転子の回転に同期して滑らかな回転磁界を作り出す構成である。

【０００５】このように永久磁石を永久磁石よりも高い透磁率を有する磁性材からなる回転子鉄心の中に配置するすなわち内部磁石回転子構成とすることによって弱め界磁が可能となり、高効率でかつ高速領域までの運転が可能となる。

【０００６】しかし、永久磁石を弱め界磁する回転電機において、高速運転時にインバータが故障すると弱め界磁制御が不能となり、永久磁石回転電機の線間には高電圧が発生し、バッテリに大きなパワーを戻すことになる。これは、第１には、急ブレーキが生じ、走行車両姿勢の不安定を招く。第２にはバッテリ，平滑コンデンサ、インバータ等を損傷せしめる可能性がある点で問題がある。

【０００７】また、上記従来技術では一般にトルク発生に寄与する永久磁石の磁束の割合が少ないためにその発生する誘起電圧は比較的小さく押さえられるが、それでも最高速での発生誘起電圧は非常に大きなものとなる。

【０００８】さらに、分布巻固定子の永久磁石電動機等の場合はスロットリプルによる誘起電圧の跳ね上がりによって一層深刻になる場合もある。

【０００９】実際には以上を避けるためには第１にはインバータと回転電機の間にコンタクタを挿入し、故障時に永久磁石回転電機をインバータより切り離す方法、第２には誘起電圧を低く設定する方法があるが、第１の方法では、コンタクタのスペース、重量等がネックで、他の電動機例えば誘導電動機に対する優位点が損なわれる。また、第２の点ではリラクタンストルク成分に期待する比率が大きく、電動機の体格を大きくすること、及びトルクを発生するのに必要な電流が増加し、インバータの電流容量をいたずらに増加させる結果を生ぜしめる欠点がある。

【００１０】本発明は故障時の誘起電圧のピーク値を低減し、これによって小形軽量，高トルクの永久磁石回転電機、及び電流容量の小さなスイッチング素子ですむインバータとを備えた永久磁石回転電機装置を提供することを目的とするものである。

【００１１】

【課題を解決するための手段】本発明は、直流電源と、それに接続されるインバータにより回転速度が制御される永久磁石回転電機と、該永久磁石回転電機を弱め界磁

制御する手段とを備えてなる永久磁石回転電機装置において、前記永久磁石回転電機の端子間の発生誘起電圧のピーク値をＶｐとし、その基本波電圧のピーク値をＶｐ１としたとき、Ｖｐ＜Ｖｐ１の誘起電圧値となさしめることによって達成される。

【００１２】本発明の好ましくは、永久磁石回転電機の端子間の発生誘起電圧の中心の電圧値をＶｍとし、その発生誘起電圧のピーク値をＶｐとしたとき、Ｖｍ＜Ｖｐの誘起電圧値となさしめたことによって達成される。

【００１３】本発明の好ましくは、永久磁石回転電機のコイル幅を永久磁石回転子の磁極の幅にほぼ等しくしたことによって達成される。

【００１４】本発明の好ましくは、永久磁石回転子の磁極中心の空隙長を磁極端の空隙長より大ならしめることによって達成される。

【００１５】本発明の好ましくは、同じ相に属する固定子巻線を巻回した複数の固定子突極が電気的にすべて同相の位置に配置することによって達成される。

【００１６】本発明の好ましくは、低回転数での定トルク範囲と高速時の定出力運転範囲とを有し、かつ定トルク範囲の最高回転数をＮ１，定出力範囲の最高回転数をＮ２としたとき、Ｎ２／Ｎ１が２以上であることによって達成される。

【００１７】

【発明の実施の形態】以下、本発明の実施例について説明する。

【００１８】図１は本発明にかかわる永久磁石回転電機装置の一実施例を、図２に本発明の永久磁石回転電機の構造を、図３に本発明の永久磁石回転電機の断面構造を示す。

【００１９】図２，図３において永久磁石回転電機は固定子１と回転子２とからなり、該固定子１は積層された鉄心からなりスロット部１１に絶縁材を介して固定子巻線３を巻装している。ここで、固定子構造は一般に広く使用されている分布巻固定子構造であって、例えば、固定子鉄心は歯部１２とて磁気回路を形成するヨーク部１３とからなり、固定子巻線３は固定子鉄心の空隙面に近い部分のスリット部１４からスロット部１１に収納される。

【００２０】回転子２は高透磁率磁性材料である、例えば珪素鋼板よりなる積層鉄心と、その積層鉄心に設けられた永久磁石挿入孔２１に挿入された永久磁石２２とシャフト４とからなる。この高透磁率磁性材料からなる積層鉄心は隣り合う永久磁石２２間に設けられた補助磁極部２３と永久磁石２２の外周に設けられた磁極片部２４とヨーク部１３とを備え、このヨーク部には前記した永久磁石挿入孔２１とシャフト４を通す孔が打ち抜かれる。この永久磁石回転子２の回転方向は反時計方向に回転し、電動機として運転するものとする。ここで、使用する永久磁石２２は直方体にしてあるため、弧状の磁石に比較して寸法精度が確保しやすく、回転子のバランス作業なしに高速回転に供することができる。また永久磁石２２には高性能磁石であるネオジウム磁石等が使用されるものとする。

【００２１】図３に本発明の永久磁石回転電機の断面構造図を示す。回転電機の固定子１は一対のハウジング１０，１０１の内周面に固定されている。ここで，固定子鉄心のスロット部１１は２４個で永久磁石回転子の極数８に対して毎極毎相あたりのスロット数が１の例で示してある。これが２，３と増加しても同様である。

【００２２】シャフト４はベアリング１０ａ，１０ｂを介してハウジング１０，１０１に回転自在に保持されている。ここで、ＰＳは回転子２の永久磁石２２の位置を検出する磁極位置検出器であり、Ｅは回転子２の位置を検出するエンコーダである。回転電機はこの磁極位置検出器ＰＳの信号と、エンコーダＥの出力信号により、制御装置を介して運転制御される構成である。Ｅは速度制御用の位置センサである。

【００２３】図１に本発明の永久磁石回転電機装置の制御回路を示す。

【００２４】図において，直流電源３０よりインバータ３１を介して多相の固定子巻線３に電力を供給する。

【００２５】速度制御回路（ＡＳＲ）３２では，速度指令ωｓと、エンコーダＥよりの位置情報θからＦ／Ｖ変換器３３を介して得られる実際の速度ωｆとから速度差ωｅを算出し，これにＰＩ制御（Ｐ：比例項，Ｉ：積分項）等によってトルク指令すなわち電流指令Ｉｓと回転子２の回転角θ１を出力する。

【００２６】一方，正弦波，余弦波発生器３４では，回転子２の永久磁石磁極の位置を検出する位置検出器ＰＳとエンコーダＥよりのパルスすなわち回転子の位置情報θから，固定子巻線３の各巻線（ここでは３相）の誘起電圧と同相の正弦波出力，あるいは必要に応じて位相シフトした正弦波出力を発生する。

【００２７】２相－３相変換回路３５においては、電流指令Ｉｓと正弦波，余弦波発生器３４の出力に応じて各相に電流指令Ｉｓａ，Ｉｓｂ，Ｉｓｃを出力する。各相はそれぞれ個別に電流制御系（ＡＣＲ）３６を持ち，電流指令Ｉｓａ，Ｉｓｂ，Ｉｓｃと電流検出器ＣＴからの電流検出信号Ｉｆａ，Ｉｆｂ，Ｉｆｃに応じた信号をインバータ３１に送って各相電流を制御する。この場合，各相合成の電流は界磁磁束に直角，あるいは位相シフトした位置（各相電流の合成の起磁力を永久磁石より９０度以上進ませる制御を弱め界磁制御という）電流を常に形成し，これによって無整流子で，かつ直流機と同等の特性を得ることができる。

【００２８】以上の構成で，制御装置によって固定子巻線３に流す電流のつくる電機子起磁力の合成ベクトルを補助磁極部２３の中心位置より回転方向側に向くように制御することによって，回転電機は，永久磁石２２によ

るトルクの他に補助磁極部２３によるリラクタンストルクを発生することができ、高トルクの電動機として運転することができる。

【００２９】以上の構成において、本発明では図１に示すように直流電源３０と、それに接続されたインバータ３１と、インバータ３１の出力端に直接接続された永久磁石回転電機とを備え、かつ永久磁石回転電機を位相シフト回路３７によって弱め界磁制御する方式の永久磁石回転電機装置において、永久磁石回転電機の端子間の発生誘起電圧のピーク電圧をＶｐとし、その基本波電圧のピーク値をＶｐ１としたとき、Ｖｐ＜Ｖｐ１の誘起電圧＊形状となさしめたことを特徴とするものである。

【００３０】電気自動車等の電動車両に使用する駆動電動機に求められるトルク特性は、低速（ある回転数までの範囲）では大トルクの発生が可能であり、かつそれを越える高速領域ではインバータ３１の容量がなるべく大きくならない範囲で定出力の運転が可能であることが望まれている。このため、低速ではインバータ３１のスイッチング素子の許容電流の範囲内での定トルク運転範囲と高速での定出力範囲での運転とを一般に行っている。

【００３１】永久磁石モータのトルクＴは一般に

$$T=(E0\cdot Iq+(Xq-Xd)\cdot Id\cdot Iq)/\omega \qquad \cdots(1)$$

ここで、Ｅ０：誘起電圧　ω：回転角速度

Ｉｄ，Ｉｑ：ｄ，ｑ軸の電流

Ｘｑ，Ｘｄ：ｄ，ｑ軸のリアクタンス

（１）式で第１項は永久磁石２２によるトルク成分で、第２項は補助磁極部２３によるリラクタンストルク成分である。

【００３２】トルクを大きくするためにはリラクタンスによるトルクと永久磁石によるトルクを最大に利用する必要がある。従って永久磁石の誘起電圧を増加させた法がインバータ３１のスイッチング素子の電流容量を小さくすることができる。

【００３３】一方、高速回転数の領域では定出力のため、必要トルクは小さくなり、リラクタンスによるトルクも永久磁石によるトルクも同一の電流に対する最大のトルクを出せる位相とはしない。ここでは、永久磁石２２の磁束を弱めて永久磁石による誘起電圧を低める、いわゆる弱め界磁制御で運転する。これによって永久磁石による誘起電圧を下げ、従って永久磁石回転電機に加える端子電圧以下にして直流電源より電力が供給されるようになって高速まで回転可能とすることができるのである。

【００３４】この条件で低速のトルクを優先させて誘起電圧を上昇させると、高速で弱め界磁を大きくする必要がある。

【００３５】ここで、制御装置か正常動作中であれば永久磁石の誘起電圧は弱め界磁制御によってインバータ３１の素子耐圧、及びインバータの入力端子間に設けられたコンデンサ等の耐圧の範囲を超えることはないが、高速運転まで正常に運行し、その後、インバータか故障した場合には弱め界磁か不能となり、大きな誘起電圧が直接インバータ３１及びコンデンサにかかり、破損のおそれと、大きな電力を直流電源に戻すことにより大きなブレーキ力を引き起こすおそれもある。

【００３６】従って、インバータの素子容量を小さくするためには大きなトルクの発生と誘起電圧の最大値を低減せしめるという合い矛盾する課題を達成する必要がある。一方、永久磁石回転電機の固定子鉄心には前述のように固定子巻線３をスロット部１１に収納するスリット１４が一般に設けられている。このスリットの影響は、図２で示したようなリラクタンストルクを積極的に利用する補助磁極部２３を有する型の永久磁石回転電機では永久磁石の角度τ１の選定によっては図４（ａ）のような波形になる。つまり中心部の誘起電圧波形Ｖｍ＝Ｖｐが大きくなってしまう。

【００３７】このような波形で高速領域でのインバータ３１の故障を考えるとインバータ３１の素子及びコンデンサの電圧耐量は誘起電圧の最大値Ｖｐで決まってしまうため、結果としてトルクに影響する誘起電圧の実行値は小さくせざるを得ず、従って、同一トルクを得るためにはインバータ素子の電流容量を増加させなければならない欠点がある。

【００３８】本発明では、図２で示した永久磁石τ１の角度をパラメータに検証した結果、角度によって誘起電圧波形に図４（ａ），（ｂ），（ｃ）のように変化することを見いだした。

【００３９】図４は８極、スロット４８個での図示例で、実線は線間誘起電圧、波線はその基本波分を示すものである。

【００４０】図４（ａ）は永久磁石τ１の角度と極節τｐの比を０．６３にした場合で、この場合、回転電機の誘起電圧の最大値Ｖｐは誘起電圧の中心部の値Ｖｍに等しく、その値は誘起電圧の基本波分Ｖｐ１よりも大きくなる。

【００４１】図４（ｂ）は永久磁石τ１の角度と極節τｐの比を０．５８にした場合で、この場合、回転電機の誘起電圧の最大値Ｖｐは誘起電圧の中心部の値Ｖｍより高く、誘起電圧の基本波分Ｖｐ１よりも小さくなる。

【００４２】図４（ｃ）は永久磁石τ１の角度と極節τｐの比を０．５３にした場合で、この場合、回転電機の誘起電圧の最大値Ｖｐは誘起電圧の中心部の値Ｖｍより大きく、誘起電圧の基本波分Ｖｐ１よりも小さくなる。

【００４３】図４（ｄ）には永久磁石τ１の角度と極節τｐの比に対するＶｐ／Ｖｐ１，Ｖm／Ｖｐを示す。

【００４４】ここで、誘起電圧の基本波分Ｖｐ１はトルクに直接関係するもので大きい方が望ましい。一方、誘起電圧の最大値Ｖｐは高速時まで運転させるにはできる

限り小さいことが望ましい。従って、Ｖｐ／Ｖｐ１の比を小さくすることが求められる。図４（ｄ）では永久磁石τ１の角度と極節τｐの比が０．６以下、つまりＶｐ／Ｖｐ１が１．０以下（Ｖｐ＜Ｖｐ１）がよい。一方、誘起電圧の中心部の値Ｖｍは直接は意味を持たないが図４（ｄ）で示すようにＶｍ／Ｖｐ＜１となる範囲と上記の範囲はよく対応している。つまりＶｐ＜Ｖｐ１はＶｍ＜Ｖｐで判彰できる。

【００４５】以上、図４（ｂ）、（ｃ）のようにすることによってインバータ素子の電流容量を小さくすることができる。

【００４６】以上の効果は、低回転数での定トルク範囲と高速時の定出力運転範囲とを有し、かつ定トルク範囲の最高回転数をＮ１，定出力範囲の最高回転数をＮ２としたとき、Ｎ２／Ｎ１の値が大きいほど効果がある。つまり，高速域で永久磁石の磁束を弱める必要が大きくなるためである。ここではこの値が２以上で上記の効果を発揮できる。

【００４７】図５に本発明の永久磁石回転電機装置の回転電機の他の実施例を示す。

【００４８】図２と同一記号は同一構成部品を示す。ここでも、同相に属する固定子巻線（例えばＵ１，Ｕ２，Ｕ３，Ｕ４）が電気的にすべて同相の位置に配置された構成で示す。同じ位相とすることによって誘起電圧の高調波がすべての固定子巻線で発生するため減衰せず、台形状の誘起電圧を発生しやすくなる。

【００４９】ここでは永久磁石回転子の中心の外周部の磁極片部２４の空隙部を大きくする構成とした。以上の形状によって図５（ｂ）に示すように永久磁石回転電機の誘起電圧は階段状となってＶｐ＜Ｖｐ１とすることができ、図４での説明と同様の効果を得ることができる。

【００５０】図６に本発明の永久磁石回転電機装置の回転電機の他の実施例を示す。図２と同一記号は同一構成部品を示す。ここでは永久磁石回転電機の固定子を集中巻としたことを特徴とする。ここでも、固定子巻線を集中的に巻回し、かつ同相に属する固定子巻線が電気的にすべて同じ位相の位置に配置された構成である。

【００５１】以上の構成とすることによって回転子はほぼ全周にわたって永久磁石を配置した構成であっても図

５（ｂ）に示すように永久磁石回転電機の誘起電圧は階段状とすることができる。これによってＶｐ＜Ｖｐ１とすることができ、図４での説明と同様の効果を得ることができる。

【００５２】なお、以上の永久磁石回転電機を電動車両、特に電気自動車に適用すれば、小型軽量高効率の永久磁石回転電機駆動装置を搭載でき、一充電走行距離の長い電気自動車を提供することができる。また、安全性の高い電動車両を提供できる。また、以上は制御装置として速度制御機能（ＡＳＲ）を有する永久磁石回転電機装置について述べたが、トルク制御機能を有する永久磁石回転電機装置についても適用可能である。また、回転電機としては軸方向の空隙を有する回転電機及び発電機，電動機及び内転型，外転型，リニア型を問わず適用可能である。

【００５３】

【発明の効果】以上の構成によれば、小形軽量，高トルクの永久磁石回転電機、及び電流容量の小さなスイッチング素子ですむインバータとを備えた永久磁石回転電機装置を提供できる。

【図面の簡単な説明】

【図１】本発明の永久磁石回転電機装置を示す。

【図２】本発明の永久磁石回転電機を示す。

【図３】本発明の永久磁石回転電機の断面を示す。

【図４】本発明の誘起電圧波形の動作説明図を示す。

【図５】本発明の永久磁石回転電機の他の実施例を示す。

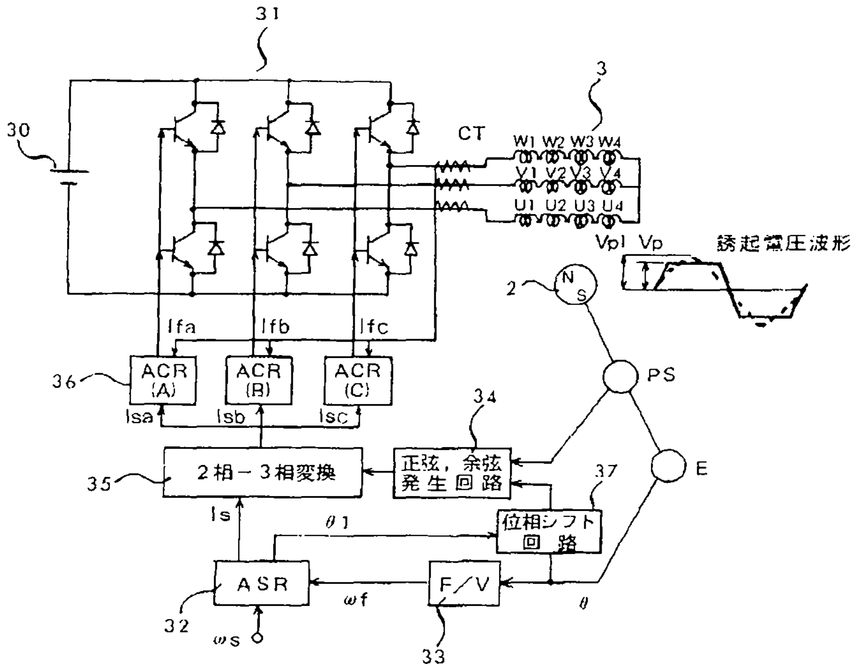
【図６】本発明の永久磁石回転電機の他の実施例を示す。

【符号の説明】

１…固定子、２…回転子、３…固定子巻線、１１…スロット部、１２…固定子歯部（突極部）、１３…固定子ヨーク部、２１…永久磁石挿入孔、２２…永久磁石、２３…補助磁極部、２４…磁極片部、３１…インバータ、３２…速度制御回路（ＡＳＲ）、３３…Ｆ／Ｖ変換器、３４…正弦波，余弦波発生器、３６…電流制御系（ＡＣＲ）、３５…２相－３相変換回路、３７…位相シフト回路。

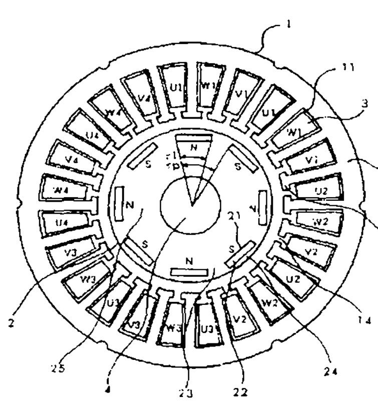
【図1】

図 1



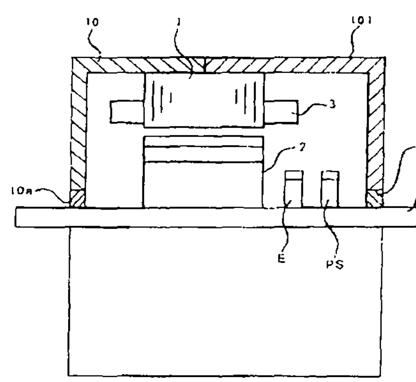
【図2】

図 2



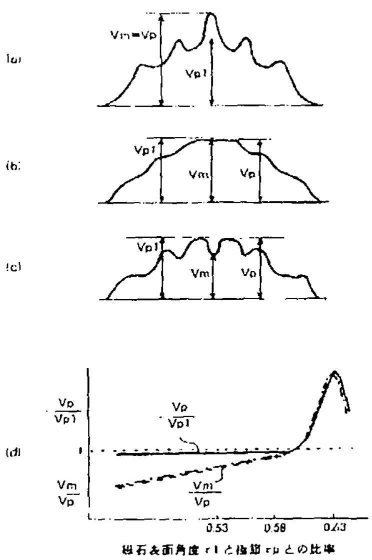
【図3】

図 3



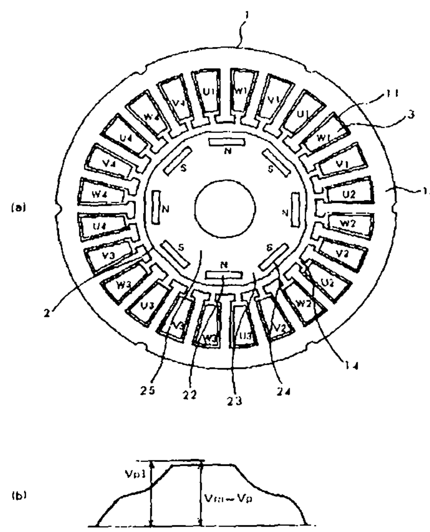
【図４】

図　4



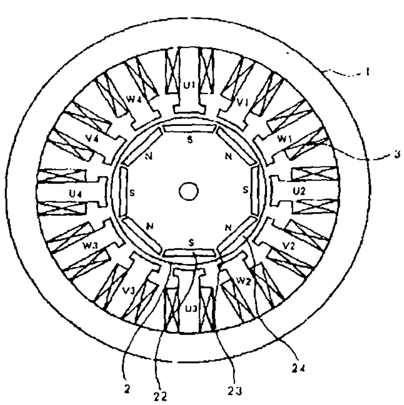
【図５】

図　5



【図６】

図　6



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